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TITLE: Adaptive pre-emphasis technique

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INVENTOR-INFORMATION:

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CLAIMS:

What is claimed is:

1. A method in a transmission medium for adaptively pre-emphasizing a transmitted signal, comprising steps of:

(a) measuring an attenuation-versus-frequency characteristic of a transmitted signal over a predetermined bandwidth of a transmission medium channel;

(b) determining an inverse of the measured attenuation-versus-frequency characteristic;

(c) storing the inverted attenuation-versus-frequency characteristic;

(d) designing filter coefficients for a pre-emphasis filter based on the stored inverted attenuation-versus-frequency characteristic;

wherein the step (d) of designing filter coefficients for the pre-emphasis filter further comprises the steps of:

(i) identifying a transmission band of said transmitted signal within said predetermined bandwidth;

(ii) finding a frequency and maximum value of said inverses of the attenuation levels within said transmission band of said transmitted signal;

(iii) subtracting said maximum value from each of said inverted attenuation levels so that a new resulting normalized peak value is at zero decibels, and all other normalized inverted attenuation levels within said transmission band are negative in decibels;

(iv) designing a pre-emphasis filter template that matches said normalized inverted attenuation levels within said transmission band, said pre-emphasis filter rolling off to negative decibel transmission levels outside said transmission band; and

(v) applying a digital filter design algorithm to determine filter weighting coefficients of a digital filter that matches said filter template; and

(e) pre-emphasizing the transmitted signal such that a cascade of the pre-emphasis filter and the transmission medium channel has a substantially flat attenuation versus frequency curve.

2. The method according to claim 1 wherein said measuring step (a) is performed at system startup.

3. The method according to claim 1 wherein said measuring step (a) is performed when a configuration of the transmission medium channel is changed.

4. The method according to claim 1 wherein said steps (a) through (e) are repeated for both forward and reverse transmission directions of said transmission medium channel.

5. The method according to claim 1, wherein said transmission medium channel is a transmission line carrying either a high-speed digital subscriber line (HDSL), a very-high-frequency digital subscriber line (VDSL), an asymmetric digital subscriber line (ADSL), integrated services digital network (ISDN), a broadband ISDN (B-ISDN), or high-definition television (HDTV) signals.

6. The method according to claim 1, wherein said transmission medium channel is a satellite communication link having at least one satellite transponder connecting first and second ground stations at either end of a link.

7. The method according to claim 1, wherein the step (a) of measuring the attenuation-versus-frequency characteristic of the transmission medium further comprises a step of determining transmission frequencies and bandwidths of all interferers within an available transmission band using spectral analysis and further determining whether a received power level of each transmission frequency is above a specified threshold level.

8. The method according to claim 7 wherein said transmitted signal comprises a sequence of test tones spaced over the available transmission bandwidth and selected to avoid those frequency transmission bands of any interfering signal detected above said specified threshold level.

9. The method according to claim 1, wherein the step (a) of measuring the attenuation-versus-frequency characteristic of the transmission medium further comprises steps of:

(f) measuring a transmitted power level of each of a plurality of transmitted test tones at a transmitter end of said transmission medium channel;

(g) measuring a received power level of each of said plurality of transmitted test tones at a receiver end of said transmission medium channel;

(h) transmitting a value of said received power levels from said receiver end back to said transmitter end; and

(i) determining an attenuation at the frequency of each of said plurality of test tones by determining a ratio of the received to transmitted signal power levels.

10. The method according to claim 9, wherein the step (b) of determining the inverse of the measured attenuation-versus-frequency characteristic further comprises the steps of:

(j) interpolating the measured attenuation-versus-frequency characteristic on a set of measurement points to calculate attenuation values on frequency values in between said measurement points; and

(k) determining the inverses of the attenuation levels at said measurement points and at all interpolated frequencies between said measurement points.

11. The method according to claim 10, wherein the interpolation of said measurement points is done using a cubic spline interpolation function.

12. The method according to claim 1 wherein the step (e) of applying the pre-emphasis filter to pre-emphasize the transmitted signal further comprises the steps of:

(l) modifying the filter weighting coefficient values of said pre-emphasis filter to equal the values calculated in steps (i) through (v); and

(m) passing a subsequent sequence of modulated values of said transmitted signal through said pre-emphasis filter for as long as said signal transmission band remains

invariant.

13. An apparatus for automatically adaptively pre-emphasizing a transmitted signal over a transmission medium, said apparatus comprising:

means for measuring an attenuation-versus-frequency characteristic of the transmitted signal over a predetermined bandwidth of the transmission medium channel;

means for determining an inverse of the measured attenuation-versus-frequency characteristic;

means for storing the inverted attenuation-versus-frequency characteristic;

means for providing filter coefficients for a pre-emphasis filter based on the stored inverted attenuation-versus-frequency characteristic;

wherein the means of providing filter coefficients for the pre-emphasis filter further comprises:

(i) means for identifying a transmission band of said transmitted signal within said predetermined bandwidth;

(ii) means for finding a frequency and maximum value of said inverses of the attenuation levels within said transmission band of said transmitted signal;

(iii) means for subtracting said maximum value from each of said inverted attenuation levels so that a new resulting normalized peak value is at zero decibels, and all other normalized inverted attenuation levels within said transmission band are negative in decibels;

(iv) means for designing a pre-emphasis filter template that matches said normalized inverted attenuation levels within said transmission band, said pre-emphasis filter rolling off to negative decibel transmission levels outside said transmission band; and

(v) means for applying a digital filter design algorithm to determine filter weighting coefficients of a digital filter that matches said filter template; and

means for pre-emphasizing the transmitted signal such that a cascade of the pre-emphasis filter and the transmission medium channel has a substantially flat attenuation versus frequency curve.

14. The apparatus according to claim 13 wherein said transmission medium channel is a high speed digital subscriber line (HDSL).

15. The apparatus according to claim 13 wherein said transmission medium channel is a very high frequency digital subscriber line (VDSL).

16. The apparatus according to claim 13 wherein said transmission medium channel is an asymmetric digital subscriber line (ADSL).

17. The apparatus according to claim 13 wherein said transmission medium channel is an integrated services digital network (ISDN).

18. The apparatus according to claim 13 wherein said transmission medium channel is a broadband ISDN.

19. The apparatus according to claim 13 wherein said transmission medium channel is a satellite communication link having one or more satellite transponders coupled to first and second ground stations at each end of a link.

20. A communication system having a transmission channel for transmitting signals between first and second terminal units, said first terminal unit adaptively pre-emphasizing said transmitted signals to compensate for electrical characteristics of said transmission channel and said second terminal unit, said first terminal unit comprising:

a forward transmission path comprising:

a digital transmitter selectively coupled for receiving a data signal, said digital

transmitter encoding the data signal in a format suitable for transmission over said transmission channel;

a pre-emphasis filter selectively coupled for either receiving said formatted data signal or bypassing said formatted data signal, said pre-emphasis filter having a filter design coupled thereto for providing a filter algorithm thereto; and

a reverse transmission path comprising:

a digital receiver for demodulating and decoding a received data signal;

a bit stream decoder coupled to said digital receiver;

a spectrum analyzer selectively coupled to receive said received data signal;

a threshold detector coupled to said spectrum analyzer; and

a control computer coupled to said digital receiver and said forward transmission path for coordinating and controlling operations therebetween such that said forward path provides test signals to said second terminal unit for spectrum analyzing the received data signal and further determining a power level thereof for designing said design filter algorithm for said digital filter for pre-emphasizing said formatted data signal, whereby the formatted data signal has a substantially flat spectrum when received by said second terminal unit.